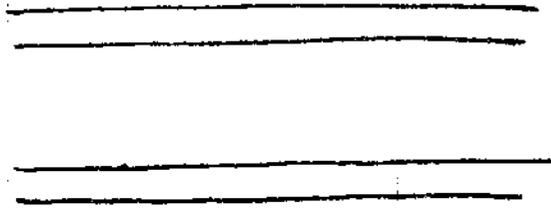


Problem 11.2

302 Stainless Steel

$D_i = 22 \text{ mm}$

$D_o = 27 \text{ mm}$



$$R_f'' = 0.0004 \text{ m}^2\text{K/W}$$

$$R_f''_o = 0.0002 \text{ m}^2\text{K/W}$$

Inside

Water

$$T_{m,i} = 75^\circ\text{C}$$

$$U_m = 0.5 \text{ m/s}$$

@ 350K

$$\mu = 365 \times 10^{-6} \text{ N}\cdot\text{s/m}^2$$

$$Pr = 2.29$$

$$\rho = 973.7 \text{ kg/m}^3$$

$$k_f = 0.668 \text{ W/mK}$$

$$Re_D = \frac{\rho U_m D_i}{\mu}$$

$$Re_D = 29344 \quad \text{Turbulent}$$

$$Nu_D = 0.023 Re_D^{4/5} Pr^{0.3} = 110.6$$

$$h_i = Nu_D \frac{k_f}{D} = 3358 \text{ W/m}^2\text{K}$$

Outside Air $V = 20 \text{ m/s}$

assume $T_f = 300\text{K}$

$$Re_D = \frac{\rho V D_o}{\mu} = 33974$$

$$\rho = 1.1614 \text{ kg/m}^3$$

$$\mu = 184.6 \times 10^{-7} \text{ N}\cdot\text{s/m}^2$$

$$Pr = 0.707$$

$$k_f = 0.0263 \text{ W/mK}$$

$$Nu_D = C Re_D^m Pr^{1/3}$$

Table 7.2 $C = 0.683$
 $m = 0.466$

$$Nu_D = 78.7 = h \frac{D_o}{k_f}$$

$$h_o = 76.2 \text{ W/m}^2\text{K}$$



Problem 11.10

2 shell passes
8 tube passes

"Shell &
Tube"

Water

$$\dot{m}_w = 45,500 \text{ kg/h}$$

$$T_{ci} = 80^\circ\text{C}$$

$$T_{co} = 150^\circ\text{C}$$

$$A = 925 \text{ m}^2$$

Exhaust Gases

$$T_{hi} = 350^\circ\text{C}$$

$$T_{ho} = 175^\circ\text{C}$$

$$\text{Water @ } 388 \text{ K} \quad C_p = 4235 \text{ J/kg K}$$

$$\text{Air @ } 535.5 \text{ K} \quad C_p = 1036 \text{ J/kg K}$$

$$C_c = \dot{m}_w C_{pw} = 53.5 \frac{\text{KW}}{\text{K}}$$

$$C_h [T_{hi} - T_{ho}] = C_c [T_{co} - T_{ci}]$$

$$C_h = 21.41 \text{ KW/K} = C_{min}$$

Find U

$$Q = C_c [T_{co} - T_{ci}] = 3745 \text{ KW}$$

$$Q_{max} = C_{min} [T_{hi} - T_{ci}] = 5780.7 \text{ KW}$$

$$\varepsilon = \frac{Q}{Q_{max}} = 0.65$$

$$C_r = \frac{C_{min}}{C_{max}} = 0.4$$

Figure 11.17 $NTU = 1.3$

$$NTU = \frac{UA}{C_{min}} \Rightarrow UA = 27.83 \frac{\text{KW}}{\text{K}}$$

$$U = 30.1 \text{ W/m}^2\text{K}$$

Problem 11.16 Counterflow - Concentric Tube
"Thin-walled"

Water $T_{ci} = 20^\circ\text{C}$
 $T_{co} = 80^\circ\text{C}$

$D_i = 20 \text{ mm}$

Oil $T_{hi} = 160^\circ\text{C}$
 $T_{ho} = 140^\circ\text{C}$

Counterflow

$\Delta T_1 = T_{hi} - T_{co} = 80^\circ\text{C}$

$\Delta T_2 = T_{ho} - T_{ci} = 120^\circ\text{C}$

Given $U = 500 \text{ W/m}^2\text{K}$
 $q = 3000 \text{ W}$

$\Delta T_{lm} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1 / \Delta T_2)}$

a)

$q = UA \Delta T_{lm}$

$\Delta T_{lm} = 98.65^\circ\text{C}$

$UA = 30.4 \text{ W/K}$

$A = 0.0608 \text{ m}^2 = \pi DL$

\downarrow
 $L = 0.97 \text{ m}$

b) after 3 years $T_{co} = 65^\circ\text{C}$

← using original values

$\frac{C_c}{C_h} = \text{Constant} = \frac{T_{hi} - T_{ho}}{T_{co} - T_{ci}} = \frac{1}{3}$

$\frac{C_w}{C_{oil}} = \frac{T_{hi} - T_{ho}}{T_{co} - T_{ci}} = \frac{1}{3}$

Find T_{ho}

$T_{ho} = 145^\circ\text{C}$

\uparrow
 $T_{co} = 65^\circ\text{C}$

$$\frac{Q}{Q_{\text{original}}} = \frac{C_c [T_{co} - T_{ci}]}{C_c [T_{co} - T_{ci}]_{\text{original}}} = \frac{45}{60} = 0.75$$

$$Q = 2250$$

$$\Delta T_1 = 95^\circ\text{C}$$

$$\Delta T_2 = 125^\circ\text{C}$$

$$\Delta T_{\text{lm}} = 109.3^\circ\text{C}$$

$$Q = UA \Delta T_{\text{lm}}$$

$$UA = 20.58 \text{ W/m}^2\text{K}$$

$$A = 0.0608 \text{ m}^2$$

⇓

$$U_2 = 338.5$$

$$\frac{1}{U_2} = \frac{1}{U_1} + R_f''$$

$$R_f'' = \frac{1}{U_2} - \frac{1}{U_1} = \boxed{0.000954 \frac{\text{m}^2\text{K}}{\text{W}}}$$

$$Nu_D = \frac{(f/8) (Re_D - 1000) Pr}{1 + 12.7 (f/8)^{1/2} (Pr^{2/3} - 1)}$$

$$Nu_D = 77.2$$

$$h_o = Nu_D \cdot \frac{k_f}{D} = 2462.5$$

Thin Walled Tube

$$\frac{1}{U} = \frac{1}{h_i} + \frac{1}{h_o}$$

$$U = 1976 \text{ W/m}^2\text{K}$$

$$h_o = 10,000 \text{ W/m}^2\text{K}$$

$$T_{sat} = 67^\circ\text{C}$$

$$q = UA \Delta T_{im}$$

Solve for A

$$A = 73.37 \text{ m}^2$$

$$A = N \cdot \pi D L$$

$$L = 1.70 \text{ m}$$

$$\Delta T_1 = T_{sat} - T_{ci} = 52^\circ\text{C}$$

$$\Delta T_2 = T_{sat} - T_{co} = 37^\circ\text{C}$$

$$\Delta T_{im} = 44.1^\circ\text{C}$$

* no correction factor required
since T_{sat} - constant

0.852 m per pass

(b) If the convection coefficient is increase by factor of (2)

$$\frac{1}{U} = \frac{1}{2h_i} + \frac{1}{h_o}$$

$$U = 3299.8$$

$$q = UA \Delta T_{im}$$

$$A = 43.9 \text{ m}^2$$

$$L = 6.02 \text{ m}$$

0.51 m,
per pass

Problem 11.53

Cross-Flow "both fluids unmixed"

Cold Side - Air

$$T_{ci} = 30^\circ\text{C}$$

$$\dot{m}_c = 0.53 \text{ kg/s}$$

Hot Side - Oil

$$T_{hi} = 75^\circ\text{C}$$

$$\dot{m}_h = 0.026 \text{ kg/s}$$

$$D = 10 \text{ mm}$$

Estimate $q_c(h)$ - fully developed
- q_s'' constant

$$Re_D = \frac{4\dot{m}}{\pi D \mu}$$

$$Re_D = 39.6 \text{ Laminar}$$

$$Nu_D = 4.36 \quad q_s'' \text{ constant}$$

$$h = Nu_D \cdot \frac{k_f}{D} = 61.5 \text{ W/m}^2\text{K}$$

Given $U = 53 \text{ W/m}^2\text{K}$
 $A = 1 \text{ m}^2$

$$C_{pair} = 1008 \text{ J/kgK}$$

$$C_f = \frac{C_{min}}{C_{max}} = 0.1$$

$$NTU = \frac{UA}{C_{min}} = \frac{53 \text{ W/m}^2\text{K}}{52.9 \text{ W/m}^2\text{K}} = 1$$

assume $T_m = 330 \text{ K}$

$$\rho = 865.8 \text{ kg/m}^3$$

$$\mu = 8.36 \times 10^{-2} \frac{\text{N}\cdot\text{s}}{\text{m}^2}$$

$$k_f = 0.141 \text{ W/mK}$$

$$Pr = 1205$$

$$C_p = 2035 \text{ J/kgK}$$

Find ε and T_{ho}

$$C_c = \dot{m}_c C_{pc} = 534.2 \text{ W/K}$$

$$C_h = \dot{m}_h C_{p, oil} = 52.9 \text{ W/K}$$

Figure 11.18

$$\varepsilon = 0.62$$

$$q_{\max} = C_{\min} [T_{hi} - T_{ci}] = 2380 \text{ W}$$

$$q = \varepsilon \cdot q_{\max} = 1476 \text{ W}$$

$$q = C_h [T_{hi} - T_{ho}] \quad C_h = 52.9 \text{ W/K}$$

$$T_{hi} = 75 \text{ }^\circ\text{C}$$

$$T_{ho} = 47.1 \text{ }^\circ\text{C}$$

